Help Us Review
Wood-Framed Wall Bracing

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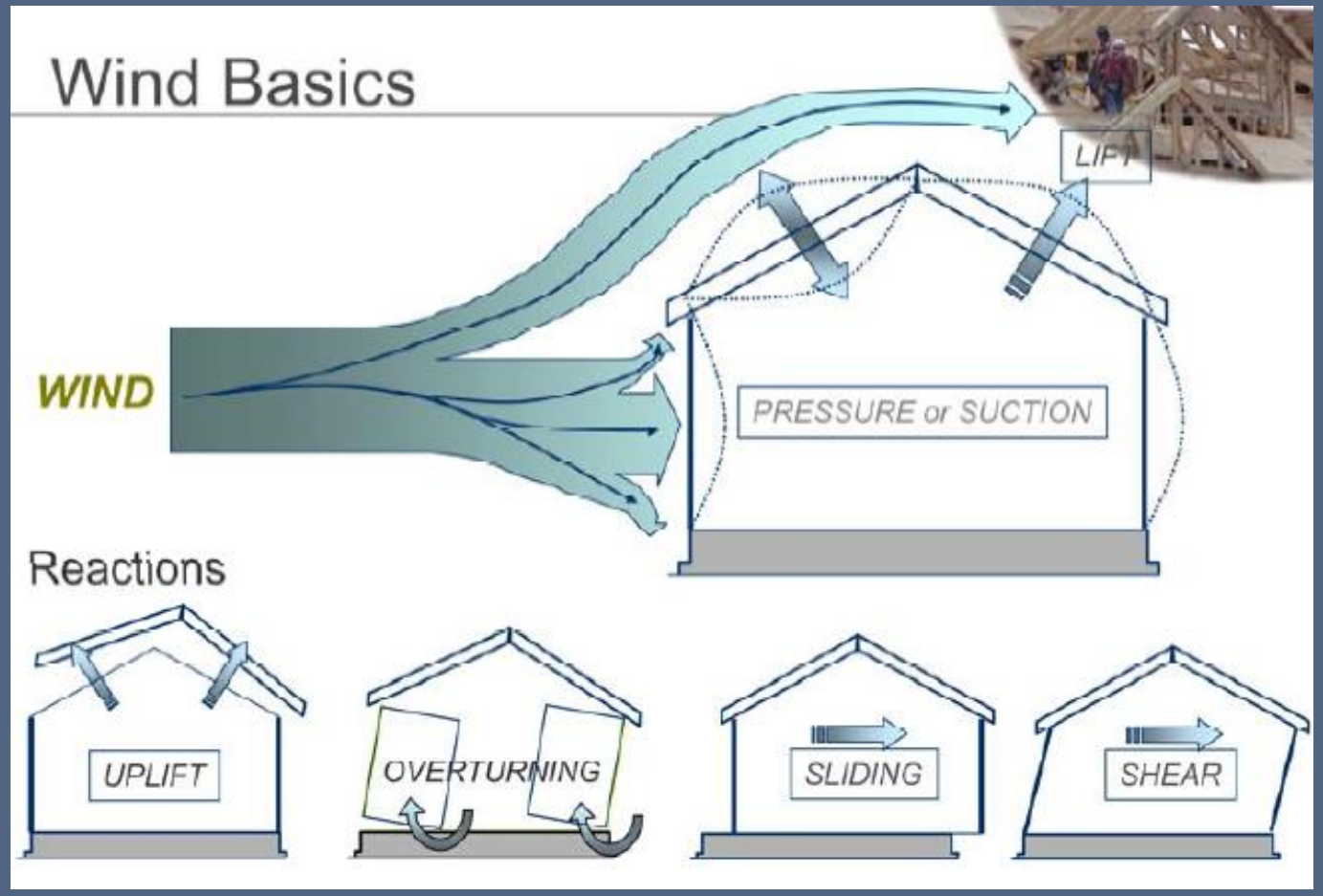
DPS | Montgomery County
Department of Permitting Services

Failure Modes



Wall Covering

Wall covering is an essential part of the first step of the load path for wind. The wall studs can be seen behind the failed wall covering system. The failure could have been due to various reasons. Approved wall coverings installed per code would most likely have been able to withstand the pressure of the wind. (Photo taken after windstorm in Evansville, Indiana.)

Not all wall coverings are by themselves capable of resisting code-required wind pressures (see IRC Table R301.2(2)). This house was subjected to an 85 mph wind. Failure could have been due to multiple issues, including improper installation or flying object damage. (Photo taken after windstorm in Evansville, Indiana.)

Roof Diaphragm

The loss of sheathing compromises the strength of the roof diaphragm. It is likely that the complexity of the connection between the roof sheathing and the step-down trusses has resulted in poor resistance to negative pressure. (Photo taken after a tornado in Fayetteville, North Carolina.)

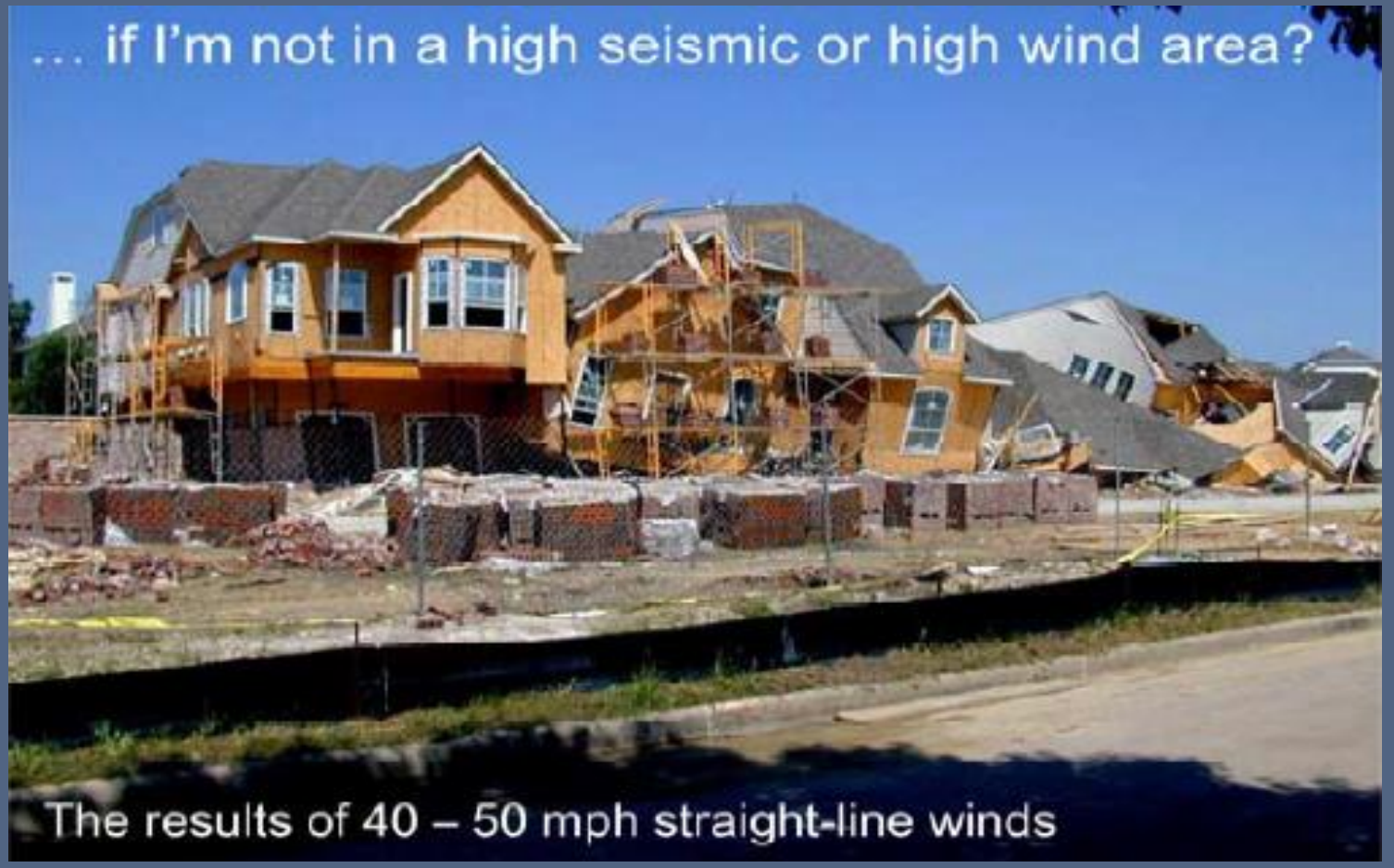
Roof-to-Wall Connections

Wall Bracing

Wall-to-Foundation Connection

A closer look at the foundation shows negligible connection of the sill plate to the foundation. The framer attempted to use nails to make this connection; however the nails are mostly bent at the tip and did not significantly penetrate the masonry foundation walls. (Photo taken after a tornado in Fayetteville, North Carolina.)

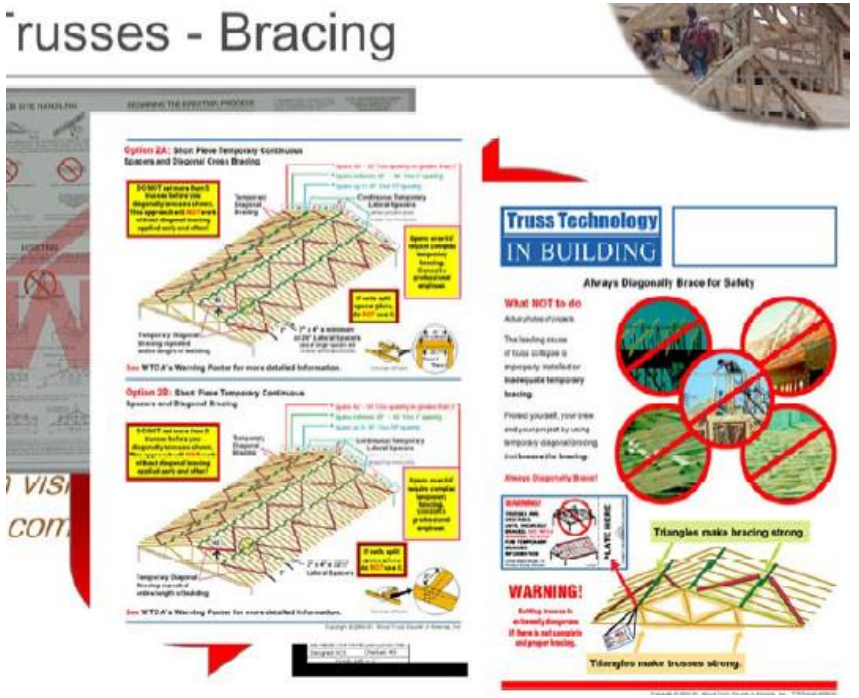
Bracing Failure During Construction



Temporary Bracing

ɔrary bracing is one of the most critical issues facing t
ry when it comes to construction safety. This Truss Te
ıg shows how critical diagonal bracing is when using s
for lateral bracing as is typical on construction sites t

TCA Warning Poster completes the educational infor
d at the jobsite to install and brace trusses safely. For
ation on bracing contact WTCA or visit the WTCA wel
voodtruss.com.

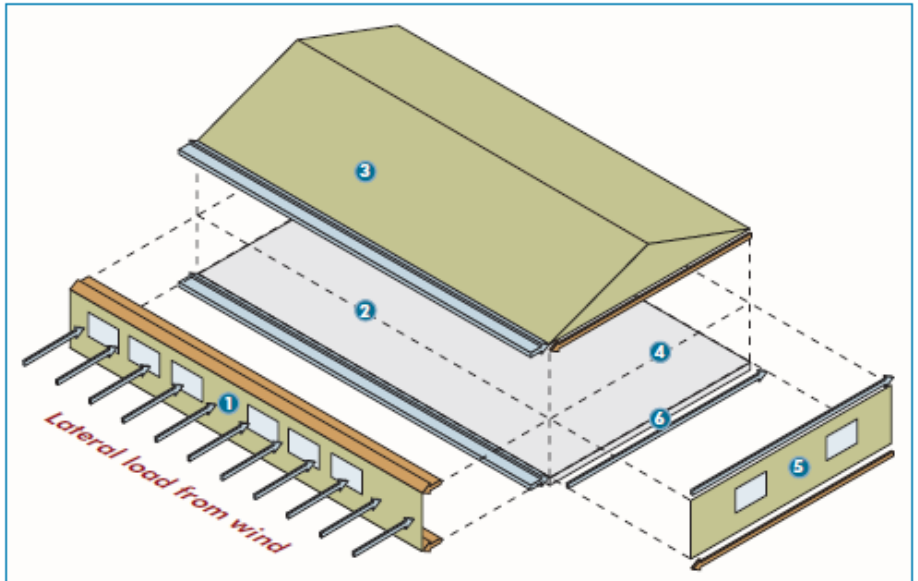


Code Requirements

Load Path

FIGURE 1.6

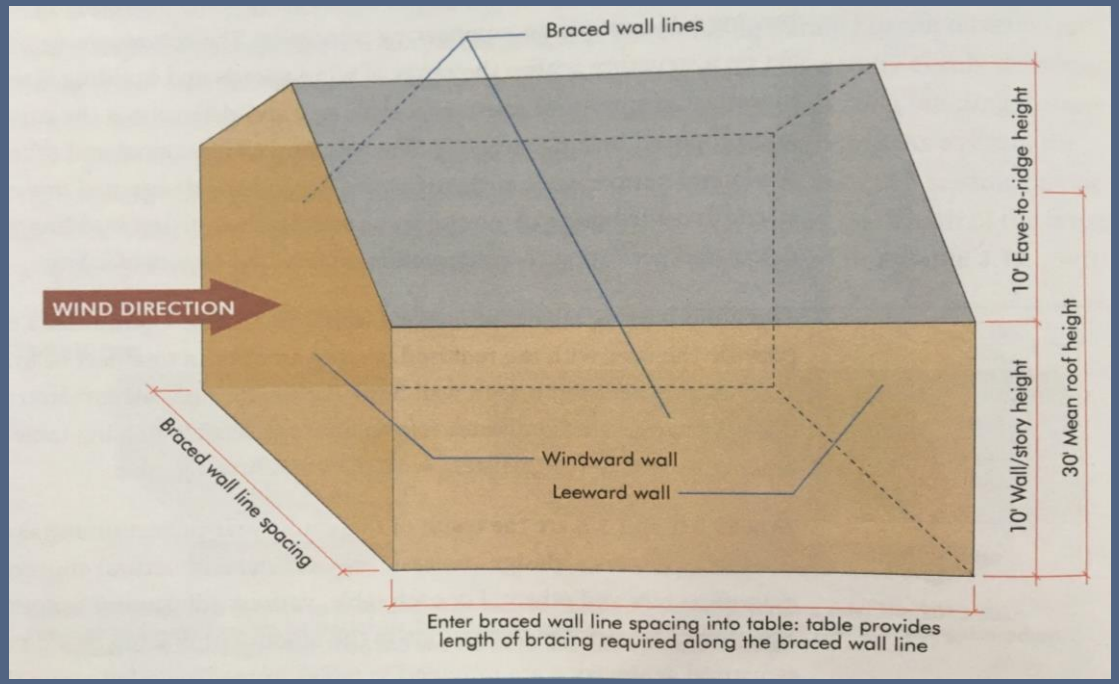
Critical parts and flow of the load path



1. Windward receiving wall carries load to foundation at bottom of wall and roof diaphragm at top of wall
2. Connections at bottom and top of wall transfer these loads into the foundation and diaphragm
3. Roof or floor diaphragm carries load to bracing walls
4. Connections between roof/floor and wall transfers load from diaphragm to bracing walls
5. Bracing wall carries load from diaphragm to foundation
6. Transfer of loads from the bracing walls to the foundation

Braced Wall Design

- Buildings shall be braced in accordance with
  - R602.10 – Prescriptive, or
  - R602.12 – Prescriptive (circumscribed rectangle)
- If prescriptive design not possible, a building, or portion thereof, use engineered design
- Note: Cladding, fasteners must be designed – IRC Table R301.2(2)



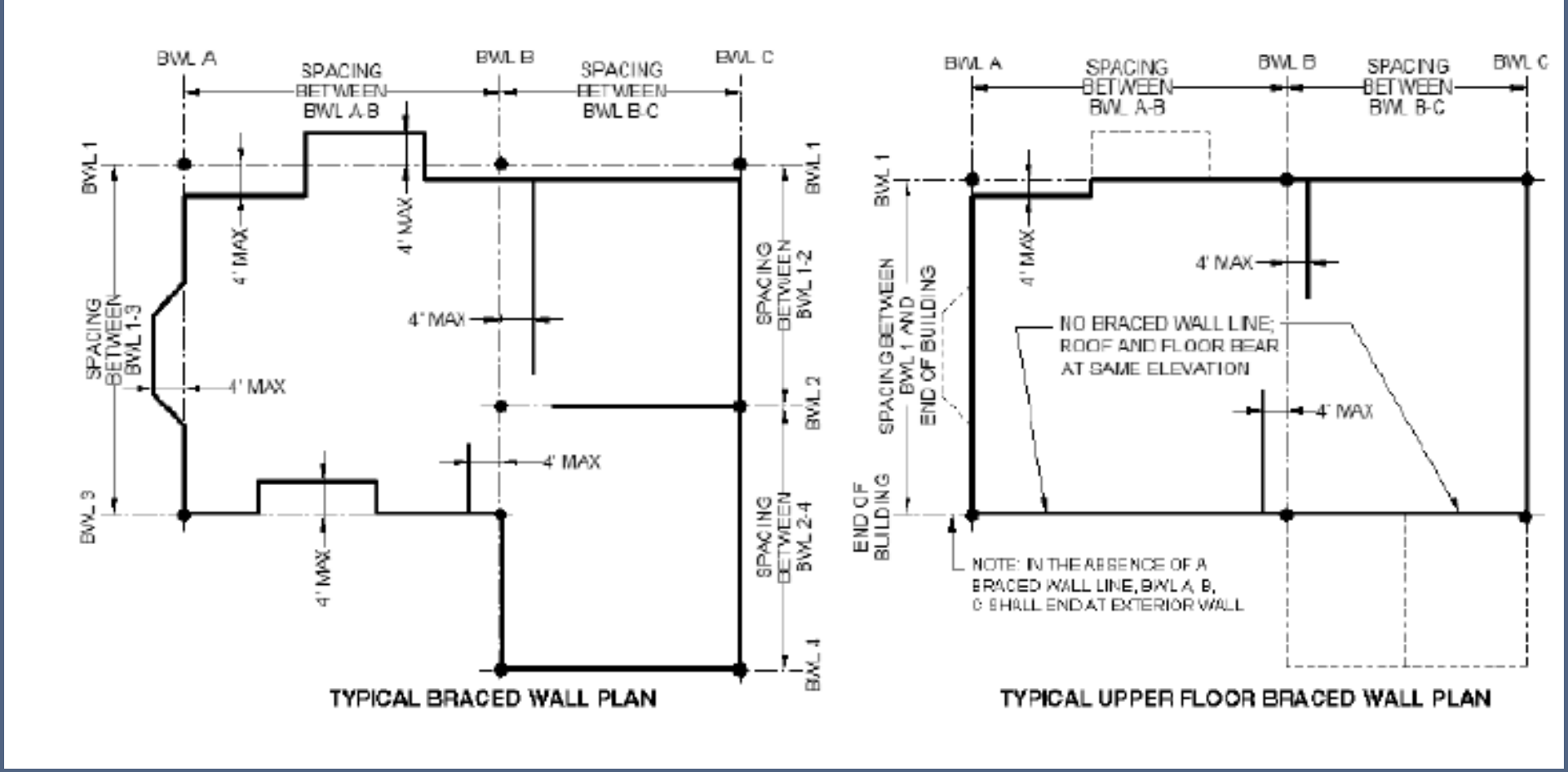
Submittal Documents

- For buildings and structures utilizing braced wall design, ~~and where required by the building official,~~ braced wall lines shall be identified on the construction documents.
- Pertinent information including, but not limited to, bracing methods, location and length of braced wall panels, and foundation requirements of braced wall panels at top and bottom shall be provided.
- Forms, spreadsheets may be used to supplement information
- CLARITY + COMPLETENESS + ACCURACY

Braced Wall Lines (BWL)

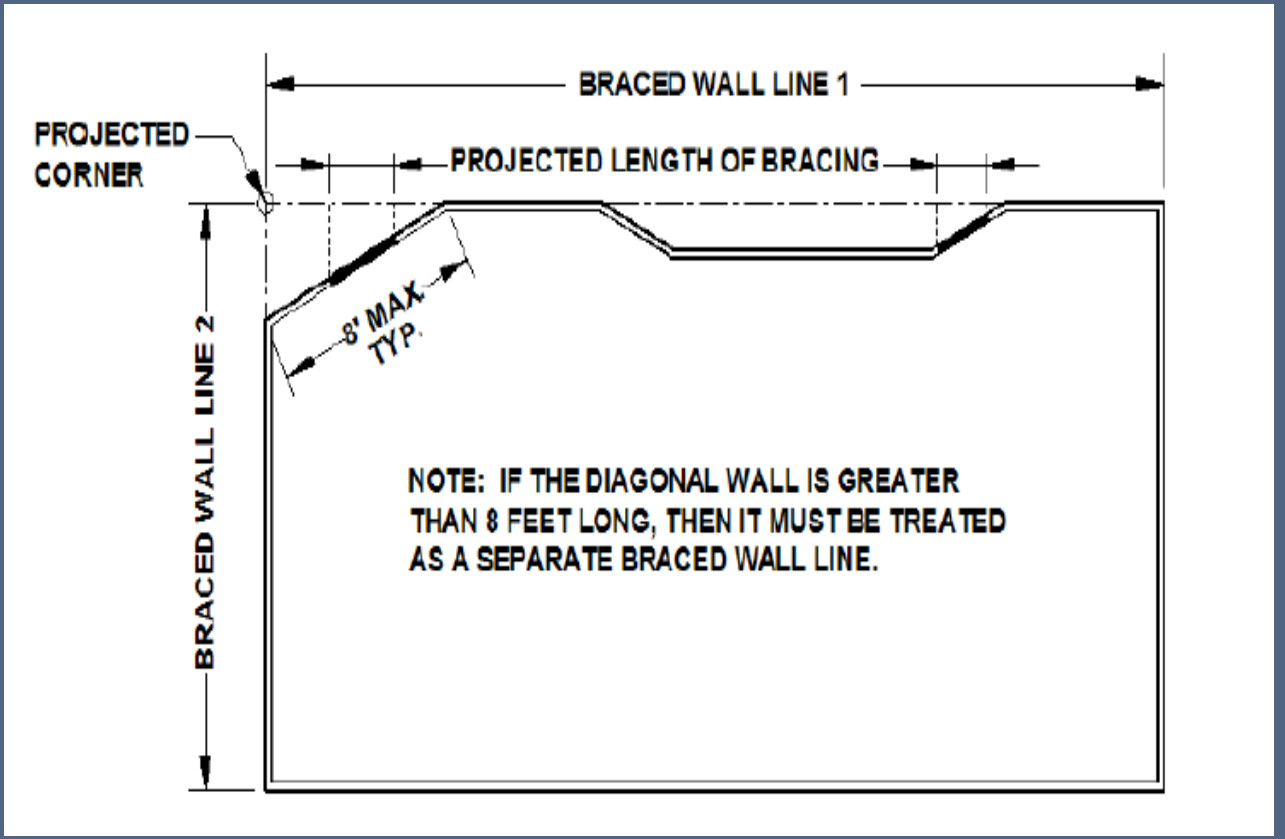
- Determines amount and location of bracing
- Straight lines, two perpendicular directions
- Spacing of braced wall lines – max 60 feet
- Required in each story
- Length of the BWL – R602.10.1.1
- Offsets along braced wall lines
  - Do not misuse imaginary line (4’ offset)

Placement of BWLs



R602.10.1

Angled Braced Wall Line

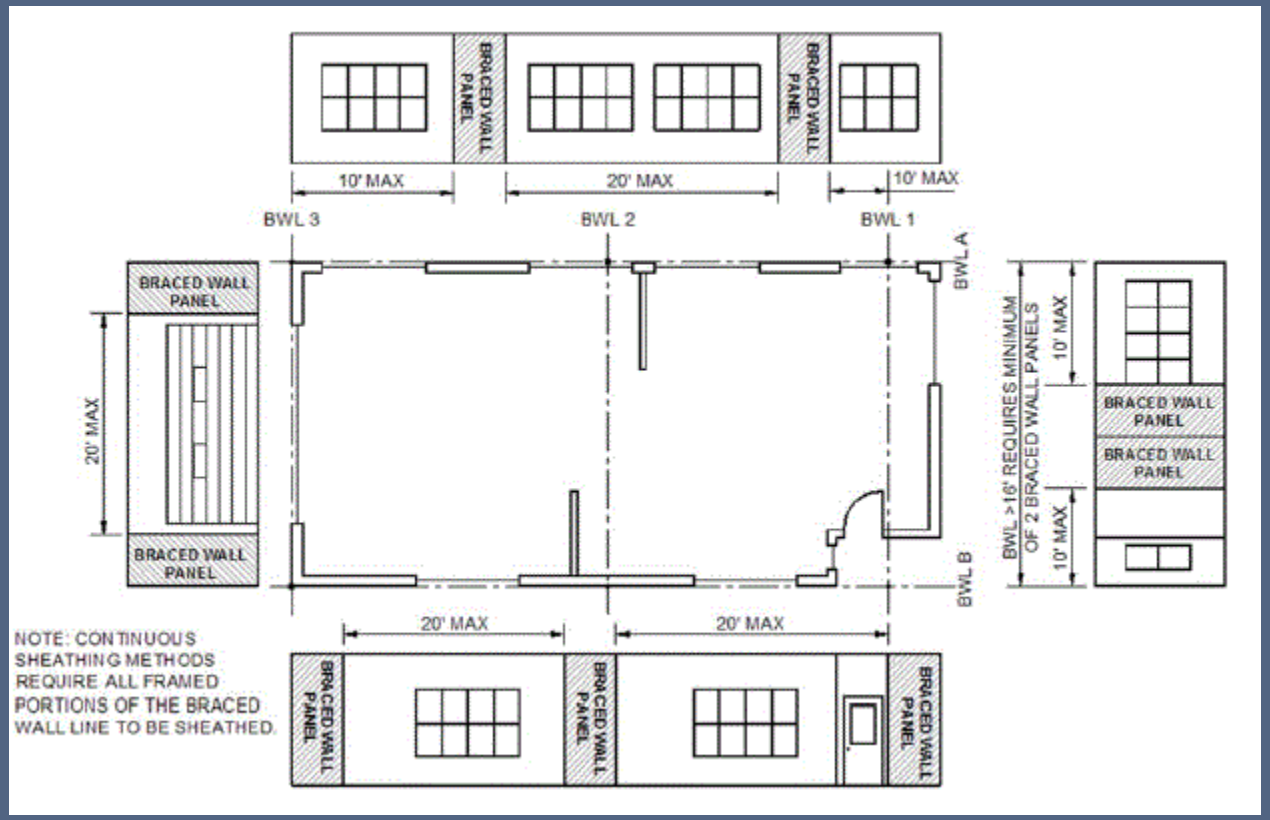


R602.10.1.4

Braced Wall Panels (BWP)

- Minimum length – from 16” to 10’, depending on the method used
- Location
- Spacing
- Quantity – R602.10.3
- Aggregate length
  - Table values
  - Adjust table values
- Compare aggregate length with code requirement

Locations Braced Wall Panels



R602.10.2.2

Braced Wall Panels Uplift Load Path

- Provide uplift continuity at BWP locations – R 602.3.5 and R802.11

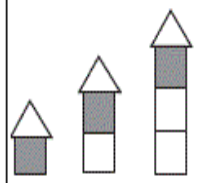
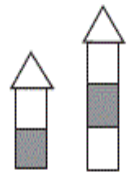
Minimum Number of Braced Wall Panels

- R602.10.2.3
- If BWL > 16 feet, two BWP any length
- If BWL < 16 feet:
  - Two of any length OR
  - Minimum one BWP equal to 48 inches

Required Length of Bracing

- Spacing
  - Traditional method – greatest length
  - Note c – average length
- Multiply tabulated value by multiple adjustment factors
- Use highest wall height along a braced wall line

TABLE R602.10.3(1)
BRACING REQUIREMENTS BASED ON WIND SPEED

• EXPOSURE CATEGORY B • 30-FOOT MEAN ROOF HEIGHT • 10-FOOT WALL HEIGHT • 2 BRACED WALL LINES			MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE[a]			
Ultimate Design Wind Speed (mph)	Story Location	Braced Wall Line Spacing (feet)	Method LIB[b]	Method GB	Methods DWB, WSP, SFB, PBS, PCP, HPS, BV-WSP, ABW, PFH, PFC, CS-SFB[c]	Methods CS-WSP, CS-G, CS-PF
≤ 115		10	3.5	3.5	2.0	2.0
		20	6.5	6.5	3.5	3.5
		30	9.5	9.5	5.5	4.5
		40	12.5	12.5	7.0	6.0
		50	15.0	15.0	9.0	7.5
		60	18.0	18.0	10.5	9.0
		10	7.0	7.0	4.0	3.5
		20	12.5	12.5	7.5	6.5
		30	18.0	18.0	10.5	9.0
		40	23.5	23.5	13.5	11.5
		50	29.0	29.0	16.5	14.0
		60	34.5	34.5	20.0	17.0
		10	NP	10.0	6.0	5.0
		20	NP	18.5	11.0	9.0
		30	NP	27.0	15.5	13.0
		40	NP	35.0	20.0	17.0
		50	NP	43.0	24.5	21.0
		60	NP	51.0	29.0	25.0

(continued)

R602.10.3

Adjustment Factors

TABLE R602.10.3(2)
WIND ADJUSTMENT FACTORS TO THE REQUIRED LENGTH OF WALL BRACING

ITEM NUMBER	ADJUSTMENT BASED ON	STORY/ SUPPORTING	CONDITION	ADJUSTMENT FACTOR[a, b] [multiply length from Table R602.10.3(1) by this factor]	APPLICABLE METHODS
1	Exposure category	One-story structure	B	1.00	
			C	1.20	
			D	1.50	
		Two-story structure	B	1.00	
			C	1.30	
			D	1.60	
		Three-story structure	B	1.00	
			C	1.40	
			D	1.70	

Adjustment Factors

2	Roof eave-to-ridge height	Roof only	≤5 feet	0.70	All methods
			10 feet	1.00	
			15 feet	1.30	
			20 feet	1.60	
		Roof + 1 floor	≤5 feet	0.85	
			10 feet	1.00	
			15 feet	1.15	
			20 feet	1.30	
		Roof + 2 floors	≤5 feet	0.90	
			10 feet	1.00	
			15 feet	1.10	
			20 feet	Not permitted	

Adjustment Factors

3	Wall height adjustment	Any story	8 feet	0.90	
			9 feet	0.95	
			10 feet	1.00	
			11 feet	1.05	
			12 feet	1.10	
4	Number of braced wall lines (per plan direction)[c]	Any story	2	1.00	
			3	1.30	
			4	1.45	
			>5	1.60	

Note c

Adjustment Factors

4	Number of braced wall lines (per plan direction)[c]	Any story	2	1.00	
			3	1.30	
			4	1.45	
			≥5	1.60	
5	Additional 800-pound hold-down device	Top story only	Fastened to the end studs of each braced wall panel and to the foundation or framing below	0.80	DWB, WSP, SFB, PBS, PCP, HPS
6	Interior gypsum board finish (or equivalent)	Any story	Omitted from inside face of braced wall panels	1.40	DWB, WSP, SFB, PBS, PCP, HPS, CS-WSP, CS–G, CS-SFB
7	Gypsum board fastening	Any story	4 inches o.c. at panel edges, including top and bottom plates, and all horizontal joints blocked	0.7	GB

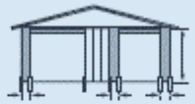
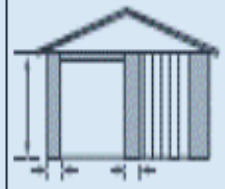
Intermittent Bracing Methods

Minimum Length 48”

METHODS, MATERIAL		MINIMUM THICKNESS	FIGURE	CONNECTION CRITERIA*	
				Fasteners	Spacing
Intermittent Bracing Method	**LIB** Let-in-bracing	1 × 4 wood or approved metal straps at 45° to 60° angles for maximum 16″ stud spacing		Wood: 2-8d common nails or 3-8d ($2^1/_2$″ long x 0.113″ dia.) nails	Wood: per stud and top and bottom plates
				Metal strap: per manufacturer	Metal: per manufacturer
	DWB Diagonal wood boards	$^3/_4$″(1″ nominal) for maximum 24″ stud spacing		2-8d ($2^1/_2$″ long × 0.113″ dia.) nails or 2 - $1^3/_4$″ long staples	Per stud
	WSP Wood structural panel (See Section R604)	$^3/_8$″		Exterior sheathing per Table R602.3(3)	6″ edges 12″ field
				Interior sheathing per Table R602.3(1) or R602.3(2)	Varies by fastener
	BV-WSP[e] Wood structural panels with stone or masonry veneer (See Section R602.10.6.5)	$^7/_{16}$″	See Figure R602.10.6.5	8d common ($2^1/_2$″ × 0.131) nails	4″ at panel edges 12″ at intermediate supports 4″ at braced wall panel end posts
	SFB Structural fiberboard sheathing	$^1/_2$″ or $^{25}/_{32}$″ for maximum 16″ stud spacing		$1^1/_2$″ long × 0.12″ dia. (for $^1/_2$″ thick sheathing) $1^3/_4$″ long × 0.12″ dia. (for $^{25}/_{32}$″ thick sheathing) galvanized roofing nails or 8d common ($2^1/_2$″ long × 0.131″ dia.) nails	3″ edges 6″ field
	GB Gypsum board	$^1/_2$″		Nails or screws per Table R602.3(1) for exterior locations	For all braced wall panel locations: 7″ edges (including top and bottom plates) 7″ field
				Nails or screws per Table R702.3.5 for interior locations	
	PBS Particleboard sheathing (See Section R605)	$^3/_8$″ or $^1/_2$″ for maximum 16″ stud spacing		For $^3/_8$″, 6d common ($2^1/_2$″ long × 0.113″ dia.) nails For $^1/_2$″, 8d common ($2^1/_2$″ long × 0.131″ dia.) nails	3″ edges 6″ field
	PCP Portland cement plaster	See Section R703.6 for maximum 16″ stud spacing		$1^1/_2$″ long, 11 gage, $^7/_{16}$″ dia. head nails or $^7/_8$″ long, 16 gage staples	6″ o.c. on all framing members
	HPS Hardboard panel siding	$^7/_{16}$″ for maximum 16″ stud spacing		0.092″ dia., 0.225″ dia. head nails with length to accommodate $1^1/_2$″ penetration into studs	4″ edges 8″ field

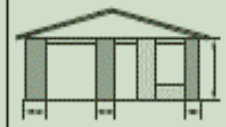
Intermittent Bracing Methods

Length 16-40”

	ABW Alternate braced wall	3/8”		See Section R602.10.6.1	See Section R602.10.6.1
Intermittent Bracing Methods	**PFH** Portal frame with hold-downs	3/8”		See Section R602.10.6.2	See Section R602.10.6.2
	PFG Portal frame at garage	7/16”		See Section R602.10.6.3	See Section R602.10.6.3

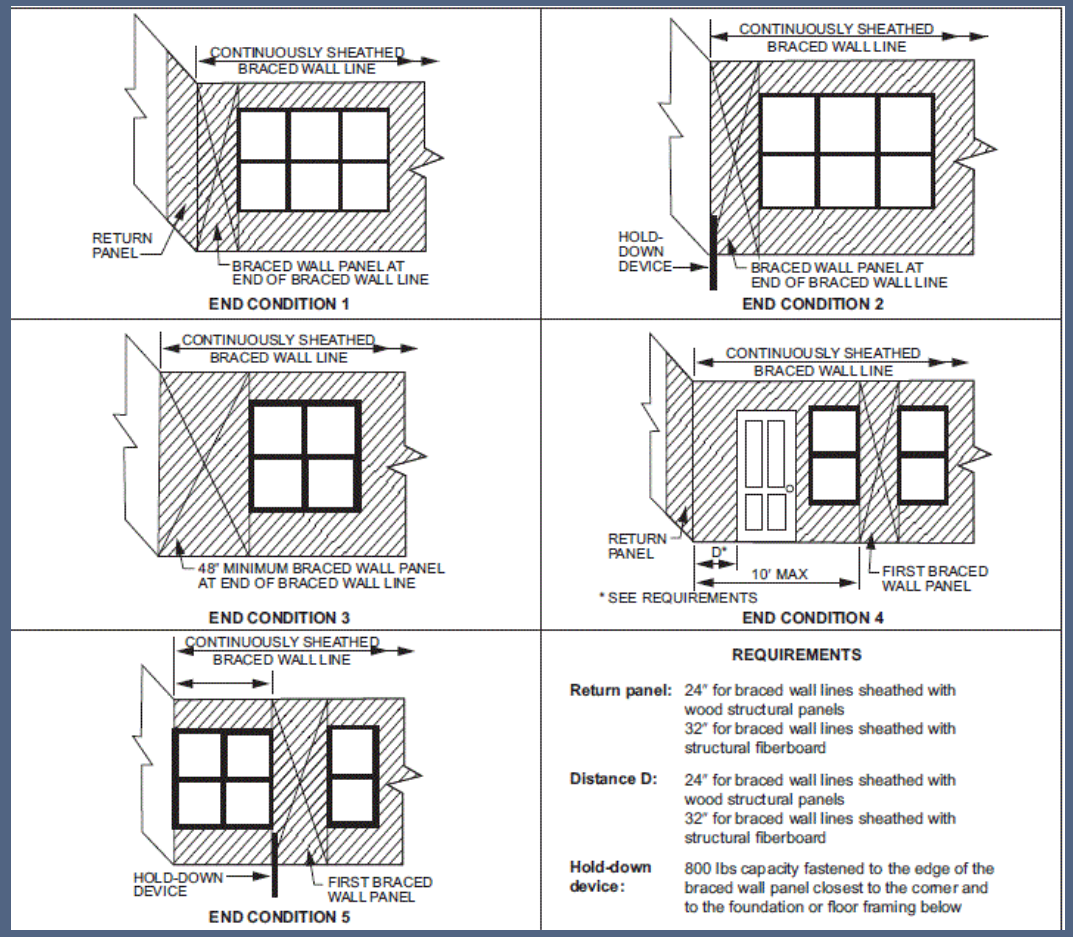
R602.10.4

Continuous Sheathing Method

Continuous Sheathing Methods	**CS-WSP** Continuously sheathed wood structural panel	$^3/_8$″		Exterior sheathing per Table R602.3(3)	6″ edges 12″ field
				Interior sheathing per Table R602.3(1) or R602.3(2)	Varies by fastener
	CS-G[b, c] Continuously sheathed wood structural panel adjacent to garage openings	$^3/_8$″		See Method CS-WSP	See Method CS-WSP
	CS-PF Continuously sheathed portal frame	$^7/_{16}$″		See Section R602.10.6.4	See Section R602.10.6.4
	CS-SFB[d] Continuously sheathed structural fiberboard	$^1/_2$″ or $^{25}/_{32}$″ for maximum 16″ stud spacing		$1^1/_2$″ long × 0.12″ dia. (for $^1/_2$″ thick sheathing) $1^3/_4$″ long × 0.12″ dia. (for $^{25}/_{32}$″ thick sheathing) galvanized roofing nails or 8d common ($2^1/_2$″ long × 0.131″ dia.) nails	3″ edges 6″ field

R602.10.4.2

Ends of Braced Wall Line CS



R602.10.7

Minimum Length

TABLE R602.10.5
MINIMUM LENGTH OF BRACED WALL PANELS

METHOD (See Table R602.10.4)		MINIMUM LENGTH[a] (inches) Wall Height 8 feet	9 feet	10 feet	11 feet	12 feet	CONTRIBUTING LENGTH (inches)
DWB, WSP, SFB, PBS, PCP, HPS, BV-WSP		48	48	48	53	58	Actual[b]
GB		48	48	48	53	58	Double sided = Actual Single sided = 0.5 × Actual
LIB		55	62	69	NP	NP	Actual[b]
ABW	SDC A, B and C, ultimate design wind speed < 140 mph	28	32	34	38	42	48
	SDC D_0, D_1 and D_2, ultimate design wind speed < 140 mph	32	32	34	NP	NP	
PFH	Supporting roof only	16	16	16	18[c]	20[c]	48
	Supporting one story and roof	24	24	24	27[c]	29[c]	48
PFG		24	27	30	33[d]	36[d]	1.5 × Actual[b]
CS-G		24	27	30	33	36	Actual[b]

Minimum Length

CS-PF	**SDC A, B and C**	16	18	20	22[a]	24[a]	1.5 × Actual[b]
	SDC D_0, D_1 and D_2	16	18	20	22[a]	24[a]	Actual[b]
CS-WSP, CS-SFB	Adjacent clear opening height (inches)						
	≤ 64	24	27	30	33	36	Actual[b]
	68	26	27	30	33	36	
	72	27	27	30	33	36	
	76	30	29	30	33	36	
	80	32	30	30	33	36	
	84	35	32	32	33	36	
	88	38	35	33	33	36	
	92	43	37	35	35	36	
	96	48	41	38	36	36	
	100	—	44	40	38	38	
	104	—	49	43	40	39	
	108	—	54	46	43	41	
	112	—	—	50	45	43	
	116	—	—	55	48	45	
	120	—	—	60	52	48	
	124	—	—	—	56	51	
	128	—	—	—	61	54	
	132	—	—	—	66	58	
	136	—	—	—	—	62	
	140	—	—	—	—	66	
	144	—	—	—	—	72	

R602.10.5

Contributing Length – Partial Credit

DWB, WSP, SFB, PBS, PCP, HPS

TABLE R602.10.5.2
PARTIAL CREDIT FOR BRACED WALL PANELS LESS THAN 48 INCHES IN ACTUAL LENGTH

ACTUAL LENGTH OF BRACED WALL PANEL (inches)	CONTRIBUTING LENGTH OF BRACED WALL PANEL (inches)[a]	
	8-foot Wall Height	9-foot Wall Height
48	48	48
42	36	36
36	27	N/A

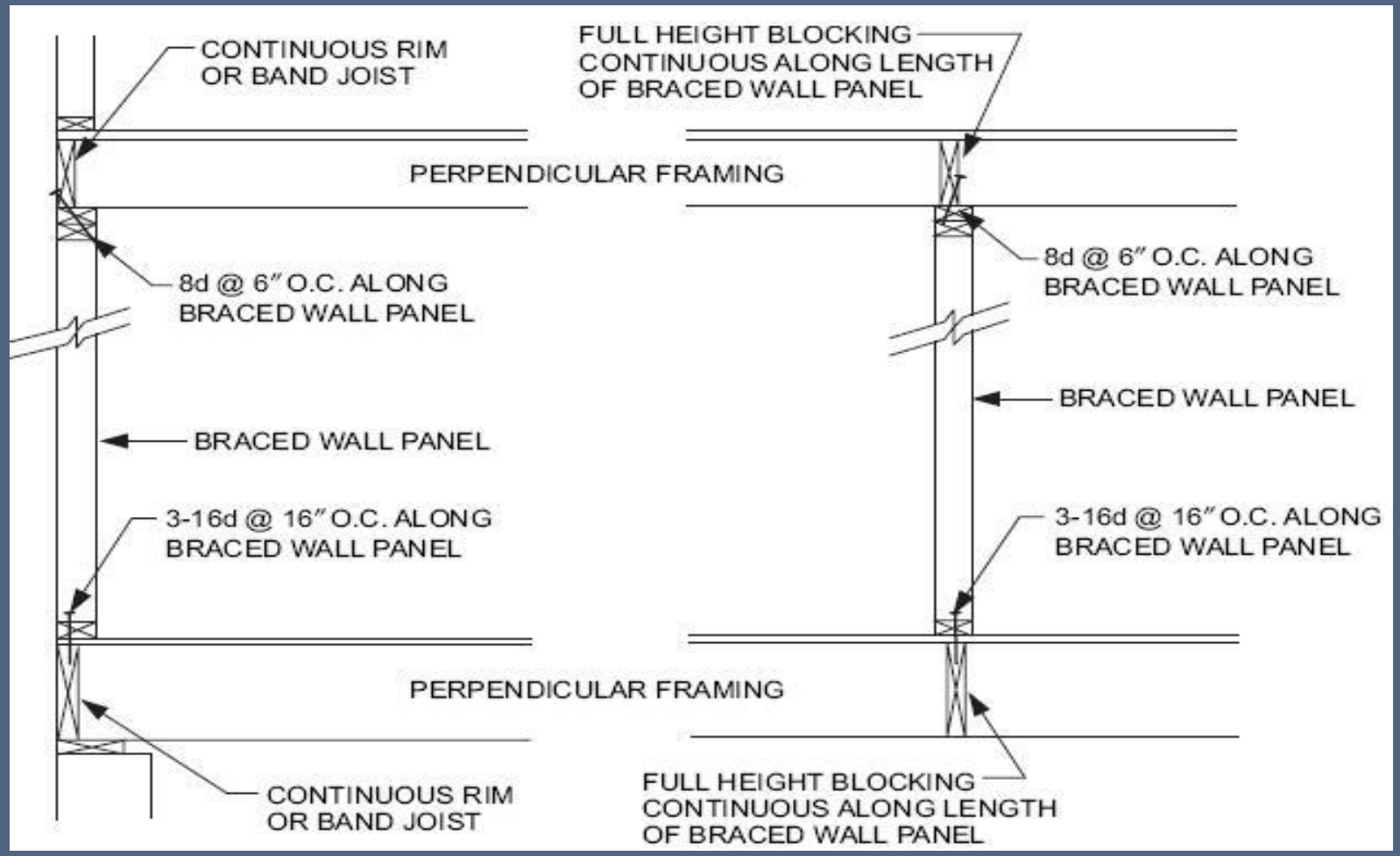
For SI: 1 inch = 25.4 mm

Mixing Methods

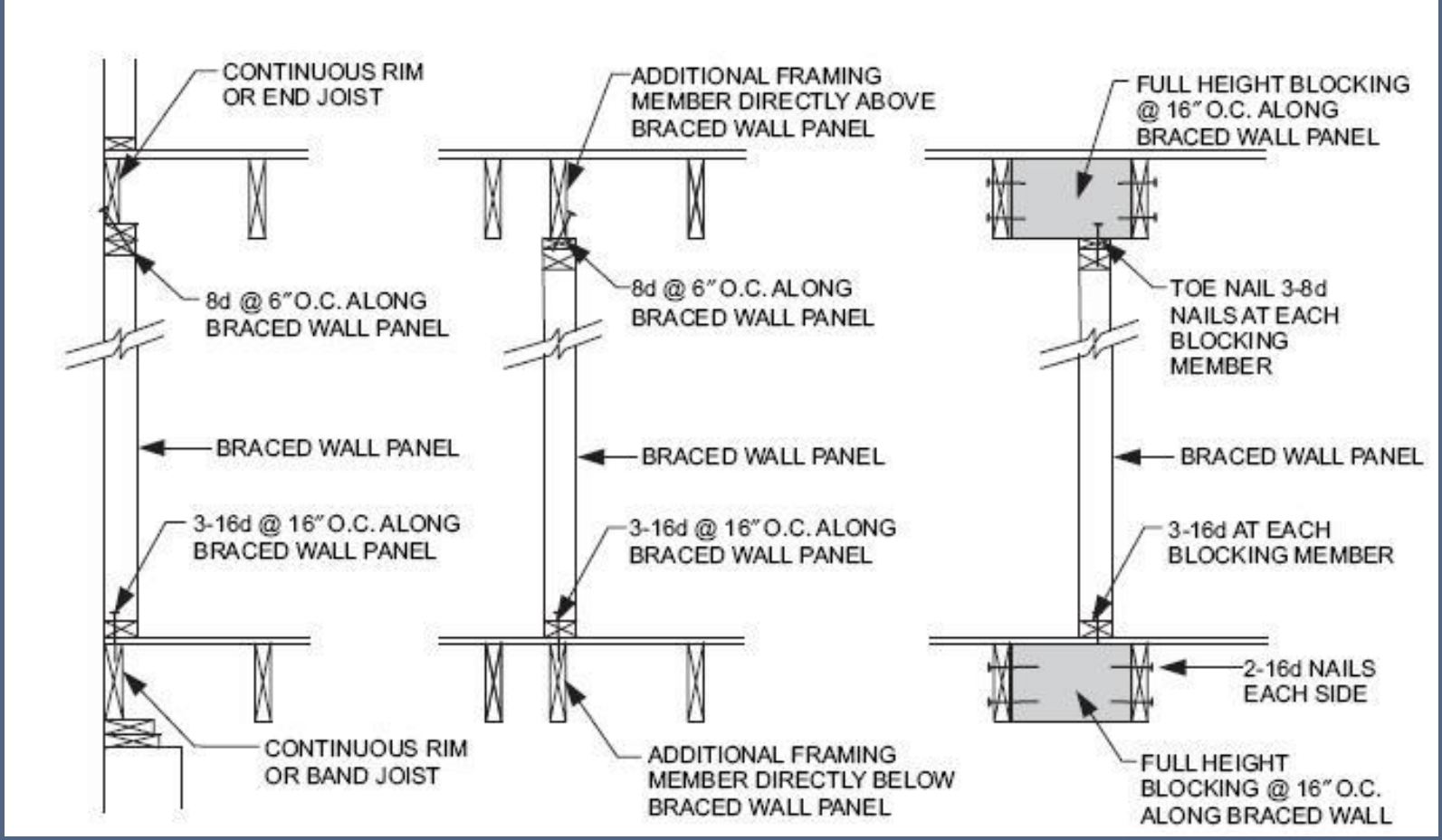
MIXING LOCATIONS	MIXING LIMITATIONS	SDC A-B	DE
Story to Story	Mixing intermittent & continuously sheathed methods	X	
BWL to BWL	Mixing intermittent methods	X	
BWL to BWL	Mixing intermittent & continuously sheathed methods	X	
Within BWL	Mixing intermittent methods in a single wall line	X	
Within BWL	Mixing continuously sheathed methods using wood structural panels only (Mixing CS-WSP, CS-G, CS-PF, ABW, PFH & PFG)	X	
Within BWL	Mixing an intermittent method on an interior portion & CS-WSP, CS-PF, and CS-G on an exterior portion of a wall line	X	

BWL = Braced Wall Line, NP = Not Permitted.

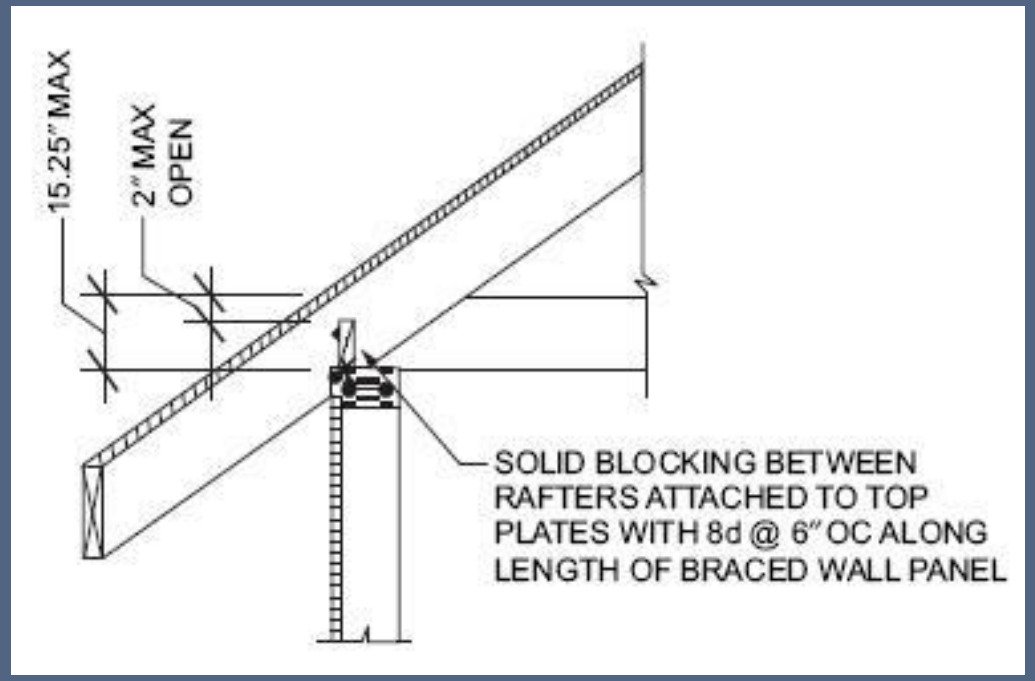
Braced Wall Panel Connections

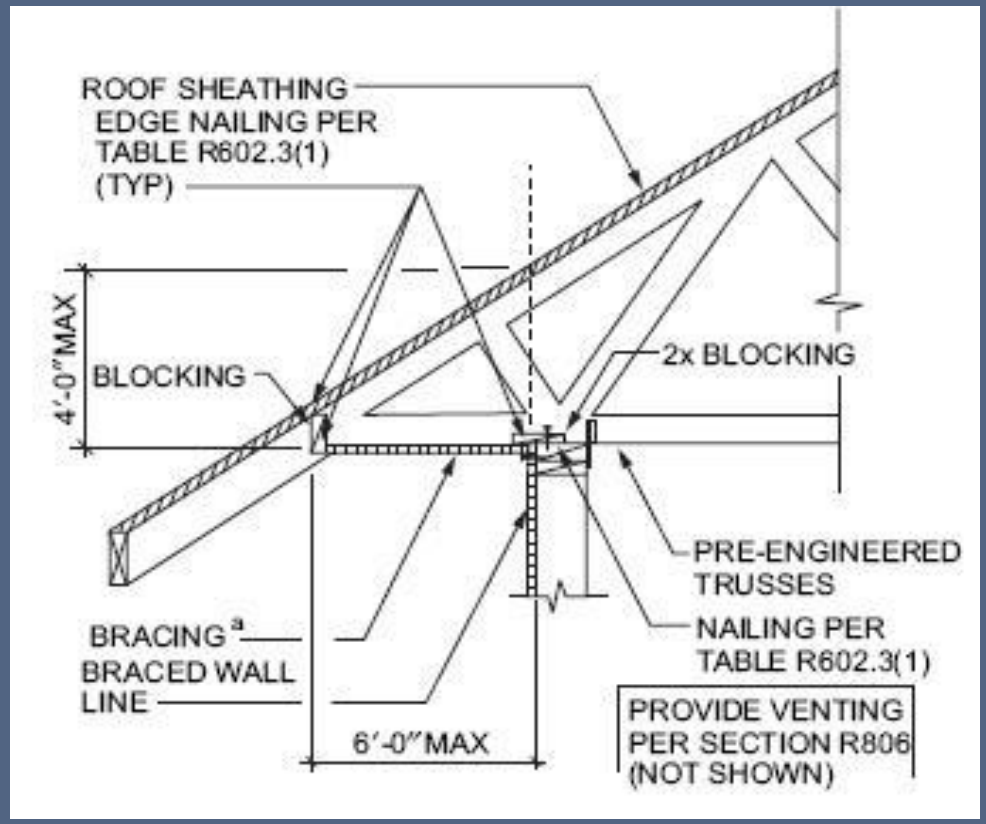


Braced Wall Panel Connections

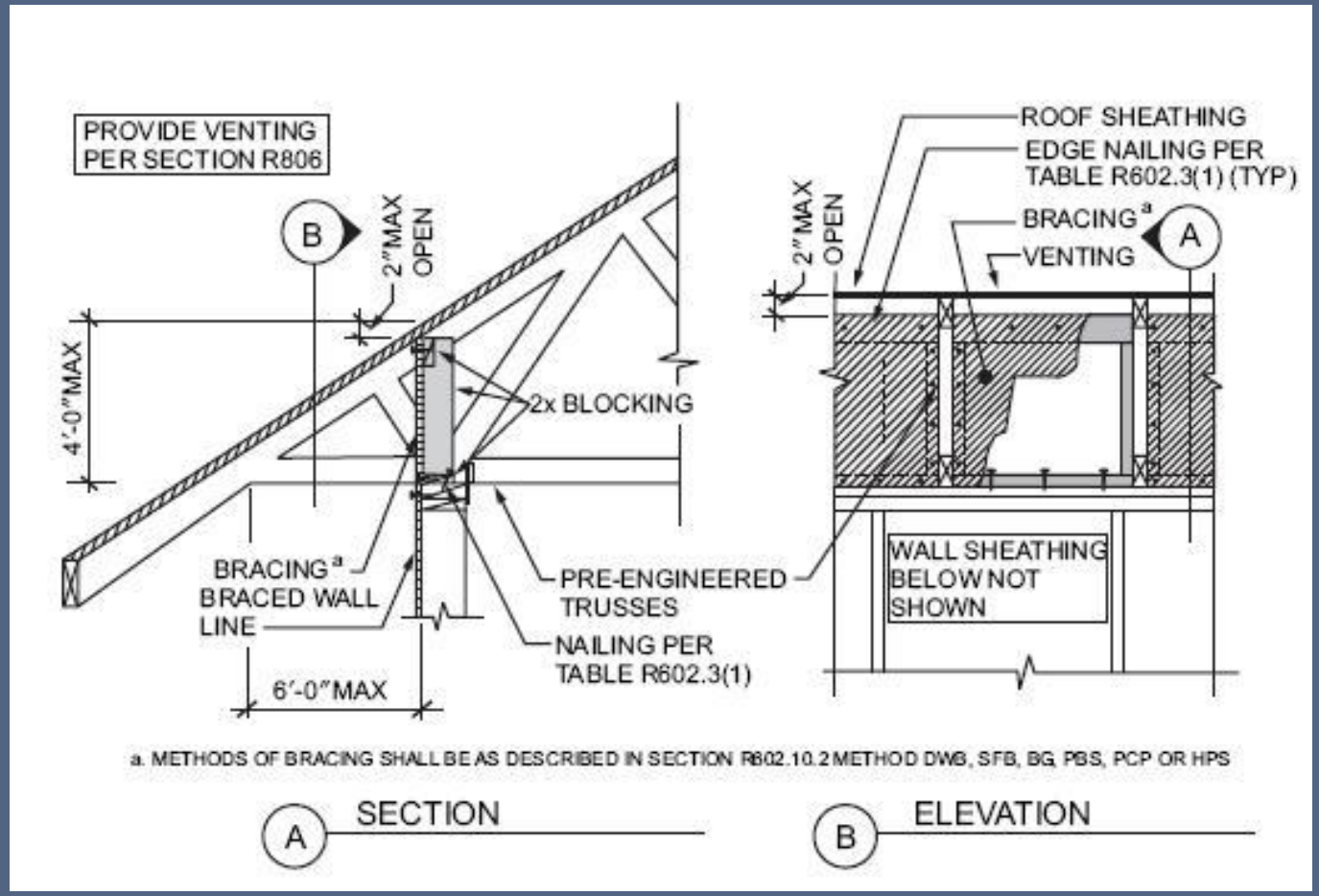


Connections to Roof Framing

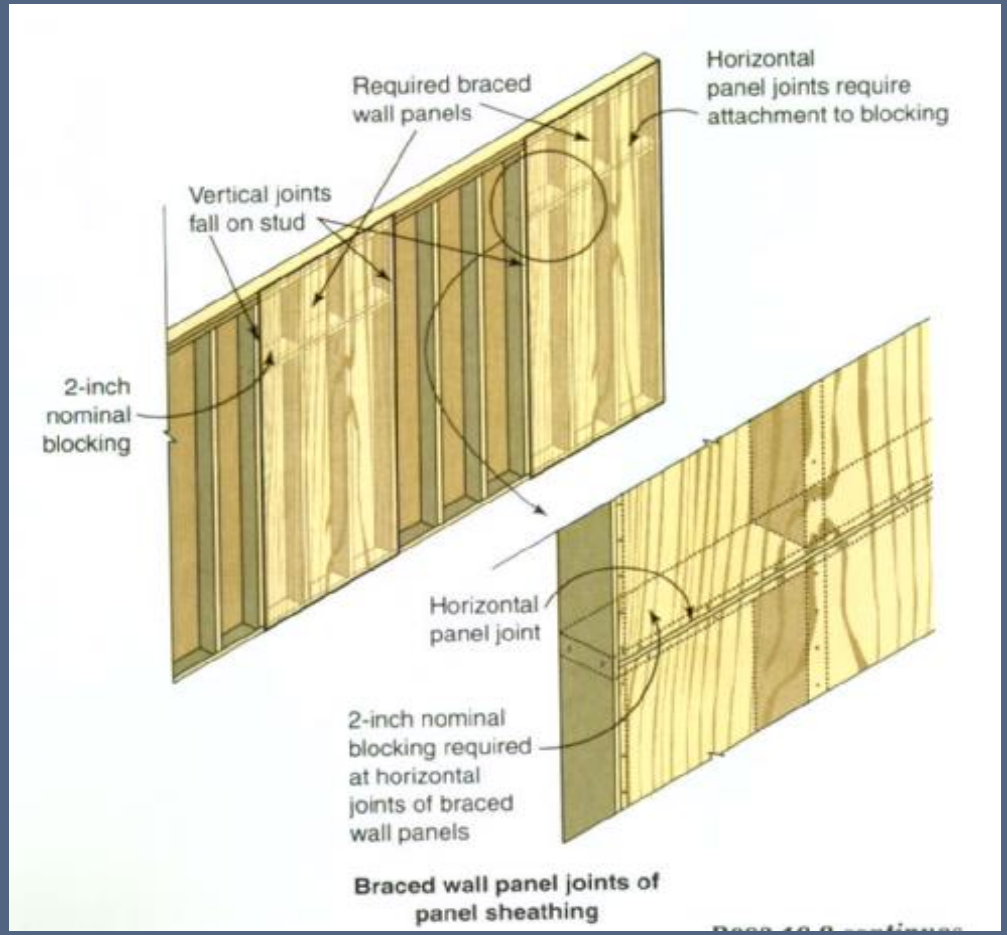




Connections to Roof Framing



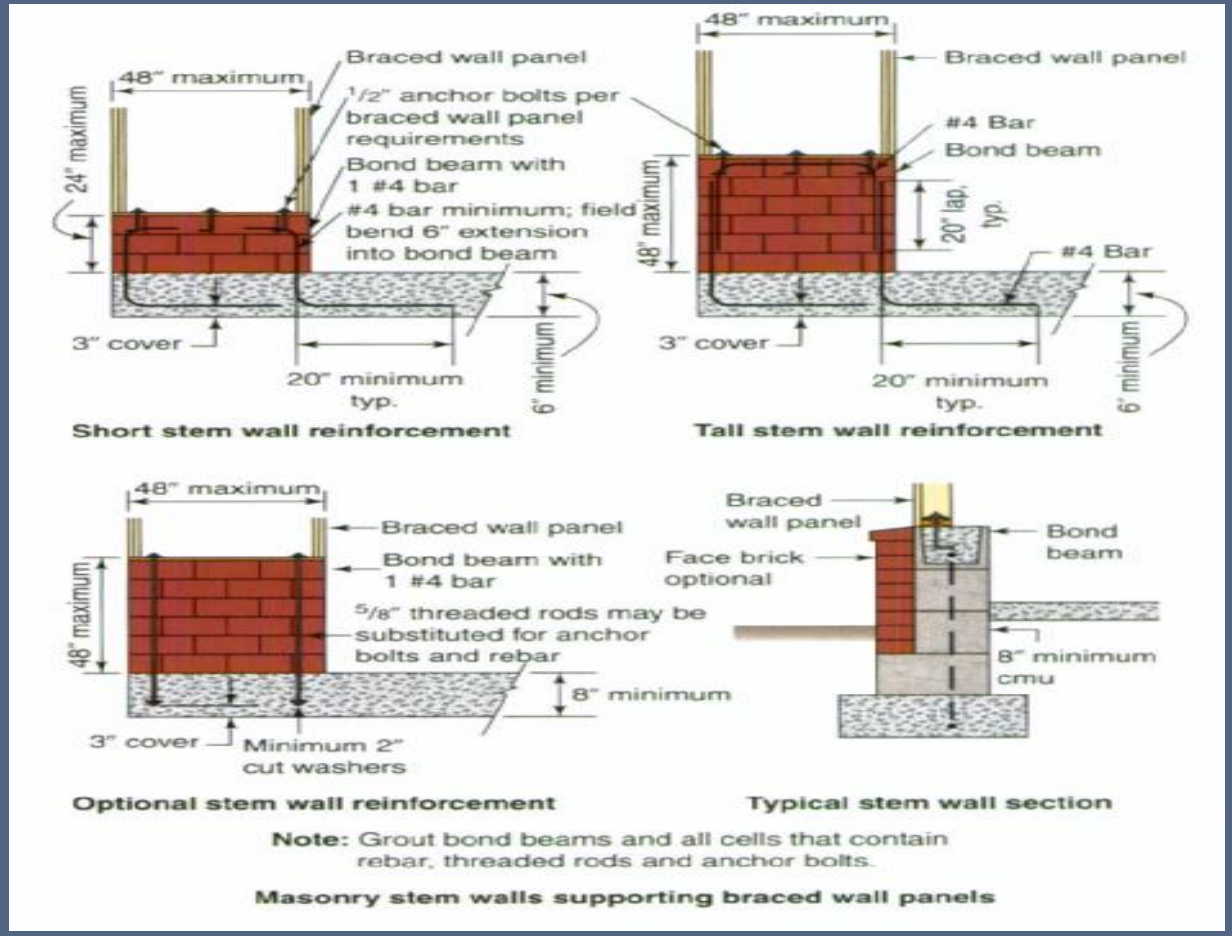
Braced Wall Panel Joints



Braced wall panel joints of panel sheathing

R602.10.10

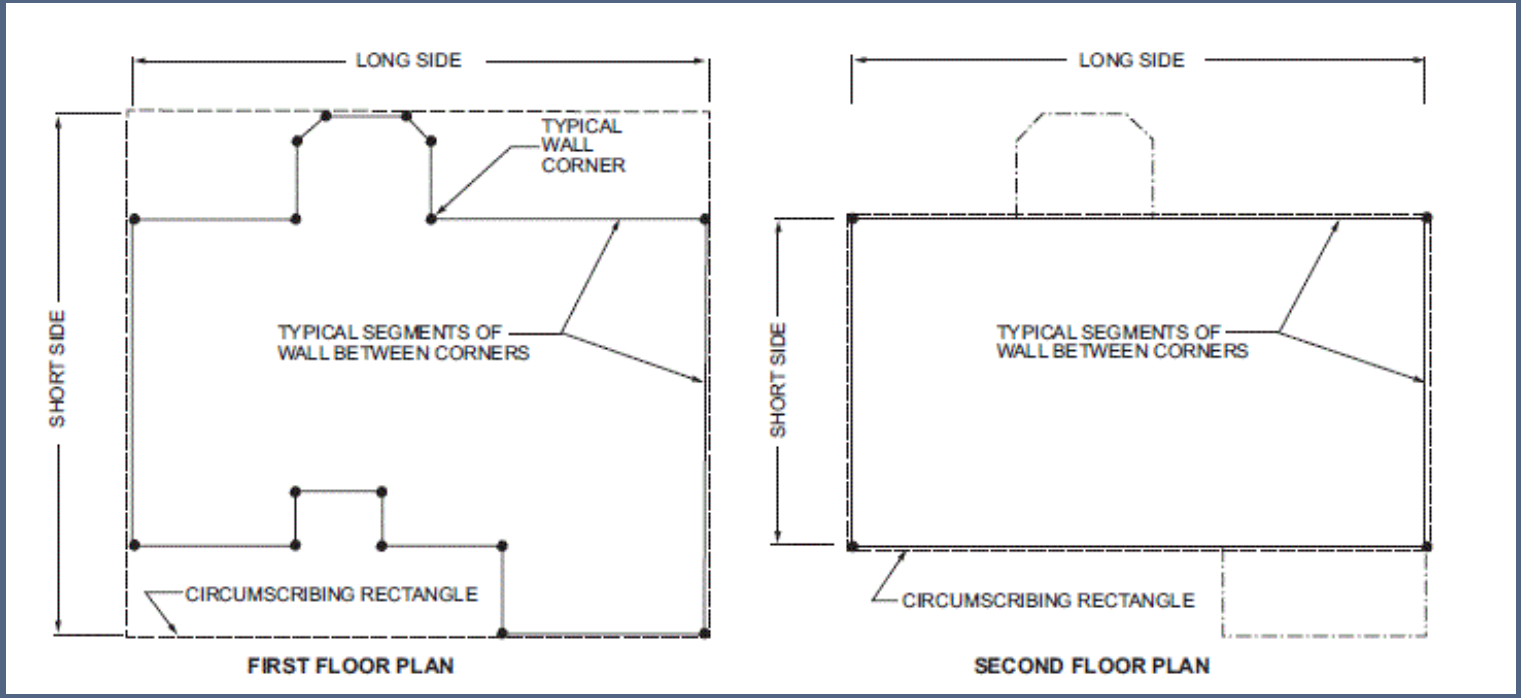
BWP Support


48" maximum
Braced wall panel
1/2" anchor bolts per braced wall panel requirements
Bond beam with 1 #4 bar
#4 bar minimum; field bend 6" extension into bond beam
24" maximum
3" cover
20" minimum typ.
6" minimum
Short stem wall reinforcement
48" maximum
Braced wall panel
#4 Bar
Bond beam
48" maximum
20" lap, typ.
#4 Bar
3" cover
20" minimum typ.
6" minimum
Tall stem wall reinforcement
48" maximum
Braced wall panel
Bond beam with 1 #4 bar
5/8" threaded rods may be substituted for anchor bolts and rebar
48" maximum
8" minimum
3" cover
Minimum 2" cut washers
Optional stem wall reinforcement
Braced wall panel
Face brick optional
Bond beam
8" minimum cmu
Typical stem wall section
Note: Grout bond beams and all cells that contain rebar, threaded rods and anchor bolts.
Masonry stem walls supporting braced wall panels

Simplified Wall Bracing

1. There shall be not more than three stories above the top of a concrete or masonry foundation or basement wall. Permanent wood foundations shall not be permitted.
2. Floors shall not cantilever more than 24 inches (607 mm) beyond the foundation or bearing wall below.
3. Wall height shall not be greater than 10 feet (3048 mm).
4. The building shall have a roof eave-to-ridge height of 15 feet (4572 mm) or less.
5. Exterior walls shall have gypsum board with a minimum thickness of $^1/_2$ inch (12.7 mm) installed on the interior side fastened in accordance with Table R702.3.5.
6. The structure shall be located where the ultimate design wind speed is less than or equal to 130 mph (58 m/s), and the exposure category is B or C.
7. The structure shall be located in Seismic Design Category A, B or C for detached one- and two-family dwellings or Seismic Design Category A or B for townhouses.
8. Cripple walls shall not be permitted in three-story buildings.

Simplified Wall Bracing

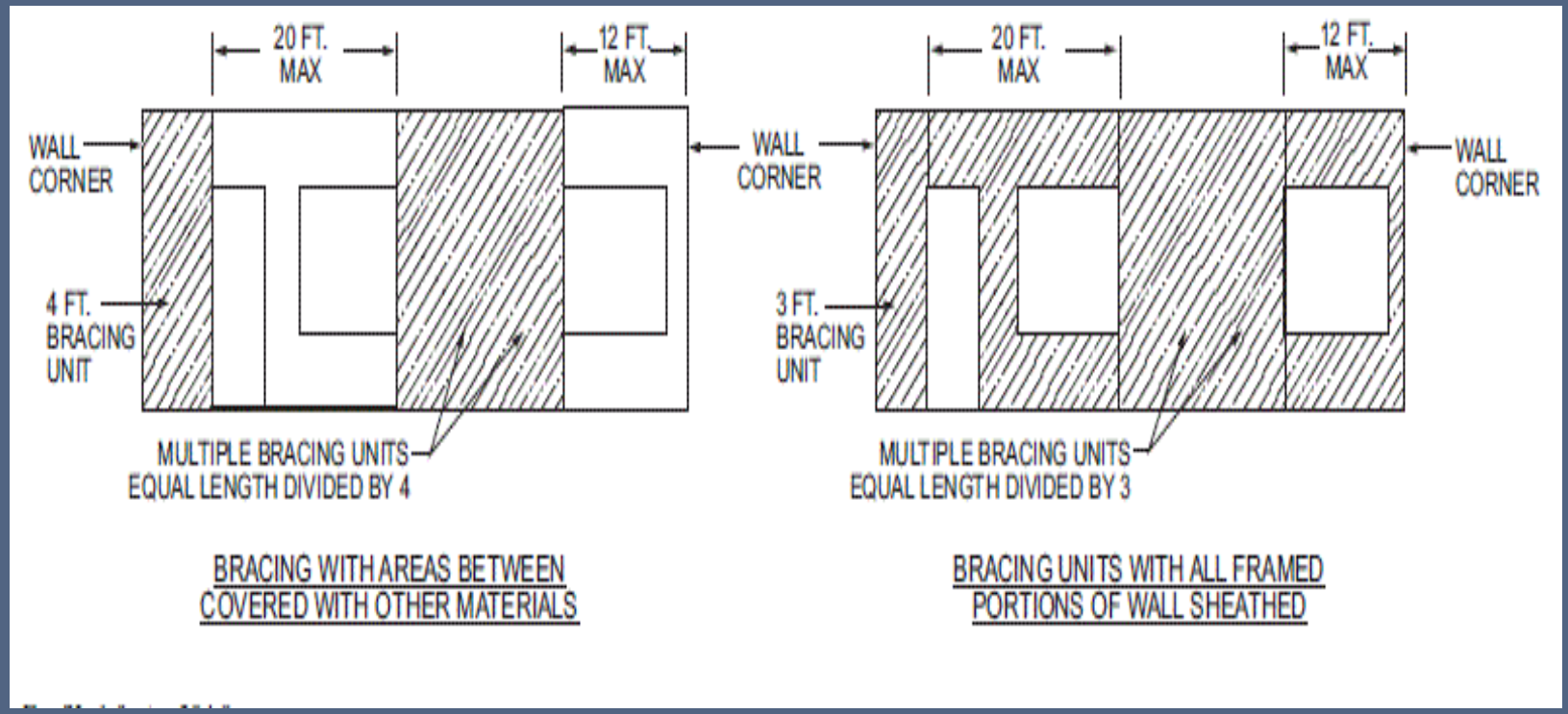


Simplified Wall Bracing

TABLE R602.12.4
MINIMUM NUMBER OF BRACING UNITS ON EACH SIDE OF THE CIRCUMSCRIBED RECTANGLE

ULTIMATE DESIGN WIND SPEED (mph)	STORY LEVEL	EAVE-TO-RIDGE HEIGHT (feet)	MINIMUM NUMBER OF BRACING UNITS ON EACH LONG SIDE[a, b, d]						MINIMUM NUMBER OF BRACING UNITS ON EACH SHORT SIDE[a, b, d]					
			Length of short side (feet)[c]						Length of long side (feet)[c]					
			10	20	30	40	50	60	10	20	30	40	50	60
115		10	1	2	2	2	3	3	1	2	2	2	3	3
			2	3	3	4	5	6	2	3	3	4	5	6
			2	3	4	6	7	8	2	3	4	6	7	8
		15	1	2	3	3	4	4	1	2	3	3	4	4
			2	3	4	5	6	7	2	3	4	5	6	7
			2	4	5	6	7	9	2	4	5	6	7	9

Simplified Wall Bracing



R602.12.4

Required Plan Review Information

- Scaled plans for wind bracing:
  - Braced Wall Lines (BWLs) Identified
  - Offsets in BWL compliant
  - BWL Supports
  - Braced Wall Line Spacing
  - Compliance Path: Prescriptive or engineered or combination
  - If Prescriptive,
    - Bracing Method
      - Intermittent or Continuous Sheathing, Mixed as allowed
      - BWPs construction, length, location, etc.
    - Determine Required Bracing Length (tabulated values)
      - 7 potential adjustments
    - Adjust Required Length
    - Is Adjusted Required Length < Provided Length
    - Contributing length of each panel
    - BWP Locations
    - BWP Connections

Resources

- IRC 2015 and Commentary
- A Guide to the 2015 IRC Wood Wall Bracing Provisions – APA/ICC

Questions

- Model House Program

http://permittingservices.montgomerycountymd.gov/DPS/pdf/ProposedModelHouseProgram.pdf

- Website Redesign